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ABSTRACT

This chapter focuses on the substantial gaps in school enrollments and cognitive achievement between boys and girls in rural Pakistan and between a relatively prosperous district (Faisalabad, Punjab) and a poor district (Badin, Sind). An important policy question is whether the allocation of educational expenditures to target disadvantaged groups will assure more equitable schooling outcomes. Surveys conducted in rural Pakistan provided data on literacy, numeracy, educational achievement, preschool reasoning ability, parental schooling and income, student school costs, and school quality. Data on 637 respondents aged 10-25 were used to assess the relative impacts of targeted improvements in schooling quality versus school quantity. By using estimated earnings functions that translate cognitive skills gains into income gains and by linking income gains to estimated costs of improvements, rates of return on investment were generated for: (1) providing a low-quality primary school (K-5) where none was available previously, (2) raising primary school quality from low to high, and (3) enabling the graduate of a low-quality primary school to complete middle school. Findings indicate that local school availability accounted for 40 percent or more of gender and regional gaps in cognitive achievement. Making even low-quality primary schools available had the highest return for all groups except girls. In all cases, raising the quality of primary schools had a substantially higher rate of return than expanding middle-school availability. Targeting educationally disadvantaged groups would involve little, if any, sacrifice in aggregate returns to society in Pakistan. Contains 55 references. (SV)

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8 Public Schooling Expenditures in Rural Pakistan: Efficiently Targeting Girls and a Lagging Region

Harold Alderman, Jere R. Behrman, Shahrukh Khan, David R. Ross, and Richard Sabot

Estimated private and social returns on education are generally high in developing countries.[1] Likewise, output accounting exercises indicate that differences in the educational attainment and cognitive skills of the labor force explain a substantial proportion of differences among countries in average labor productivity (Knight and Sabot 1987; Krueger 1968). In addition to raising their productivity, schooling tends to augment the income, wealth, nutrition, and health of the educated and to decrease the quantity, and improve the "quality," of their children.

In no society is the distribution of schooling equal. Instead, there are systematic, group-based differences in the probability of going to school. In particular, in many developing countries there are large differences between genders and among regions in educational opportunities and in the quality of schooling. Recent surveys indicate that the gaps favoring boys over girls in schooling enrollment and attainment vary considerably across countries but tend to be relatively large in South Asia, in the Middle East, and in North Africa (Behrman 1993; King 1990; King and Hill 1993). Country case studies indicate substantial regional gaps in schooling, with particularly low levels of attainment in such regions as the Northeast in Brazil, northern Nigeria, northeastern Thailand, and the Sind in Pakistan.

In this chapter, we focus on rural Pakistan, where the gender and regional gaps are large.[2] Our survey evidence for 1989 indicates sub-

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Table 8-1. Gender and Regional Gaps in Selected Schooling Indexes

Gender or region	Primary school enrollment rate (10–18 cohort, percentage)[a]	Cognitive achievement (20–24 cohort, percentage)[b]	Availability of primary school (10–18 cohort, percentage)[c]
Boys	74.6	15.7	98.2
Girls	38.0	3.8	60.1
Faisalabad	73.8	11.5	93.0
Badin	34.8	3.2	57.3

a. The primary school rate gives the percentage of individuals in the ten to eighteen year old cohort of the gender or in the region indicated who ever have enrolled in primary school.

b. Cognitive achievement is measured by reading and mathematics tests that are described in some detail in the text.

c. The availability of a primary school refers to whether a primary school was available locally at the time that an individual in the sample was of primary school age.

stantial gaps in schooling enrollments and cognitive achievement between boys and girls and between a relatively prosperous district, Faisalabad in the Punjab, and a relatively poor district, Badin in the Sind (see table 8-1).[3] Boys are twice as likely as girls to start school in our sample. This contributes to a gender gap in cognitive skills of 76 percent. That is, for persons aged twenty to twenty-four, the mean score for women on a test of literacy and numeracy (3.8 points out of a maximum of 72) is 76 percent of the male score (15.7 points). Comparing the regions, nearly three-fourths of children in Faisalabad start school, while barely a third start school in Badin. The gap in mean cognitive achievement scores between these regions is 72 percent.

These gender and regional divergences in schooling in rural Pakistan, and those elsewhere in the developing world, raise an important issue. When allocating education expenditures, should the disadvantaged groups—including girls and children in lagging regions—be targeted in order to assure more equitable gains from schooling? This in turn raises three related questions.

First, how important is the supply side relative to the demand side in the determination of gender and regional gaps in schooling attainment and achievement? The supply of public schools can be controlled directly by governments, whereas the demand for schooling cannot. If the conventional wisdom is correct and gender and regional gaps are largely due to gaps in demand, then, in Pakistan, targeting more schooling resources toward schooling for girls and children in Badin would not have much of an effect.

Second, if supply-side factors indeed are important, on which dimensions of supply should interventions focus? To attain the desired targeted reduction in cognitive achievement gaps, would it be more cost-effective, for example, to increase the number of primary schools of a given quality, to increase the number of middle schools of a given quality, to increase the quality of existing primary schools, or to increase the quality of existing middle schools? If it is worth attempting to target schooling investments, it is desirable to do so in the most cost-effective way.

Third, does targeting force a trade-off between greater equity and reduced productivity, or might both equity and productivity be enhanced by effective targeting? How do the rates of return on targeted investments compare with those to other potential uses of the same resources?

In this chapter, we attempt to answer these questions using a special data set for rural Pakistan designed and generated, in part, with these questions in mind. The first section summarizes the evidence that has led us to conclude that differences in the supply of schools are strongly associated with the gender and regional schooling gaps. Next, we present the simple schooling demand/supply analytic framework we use to assess the relative rates of return on improving the quality and increasing the quantity of schooling. The following section describes the data used in the analysis. Our survey permits us to go beyond previous analyses of the relative returns on changes in the quality and quantity of schooling. It links households with the schools attended by household members. One questionnaire and a set of tests were administered in surveyed households. Another questionnaire and the same set of tests were administered to teachers in surveyed schools. The data set contains, inter alia, measures of preschool ability; a wide range of school "quality" characteristics, some of which—for example, the preschool ability and cognitive achievement of teachers—have not previously been available; other inputs into the education production process; cognitive outputs (literacy and numeracy) of the education production process; and the earnings of employed members of the household.[4] The next section presents estimates of the impact of schooling quality and quantity on cognitive achievement and—through cognitive achievement—on daily earnings in labor markets. This section also presents the implied rates of return on investments in school quality versus quantity for girls and for children in Badin. These estimates permit us to answer the second and third questions posed above. The final section presents our conclusions.

Most studies that have investigated the impact of schooling quality in developing countries focus on its influence on grades or test scores, not on postschool outcomes, and have limited controls for preschool ability and for family and community background. These estimates have yielded mixed results with regard to the magnitude, significance, and even signs of the effects of some variables (for example, teacher/student ratios), but they do fairly consistently find evidence of an

impact on achievement of variation in some school inputs such as textbooks and materials.[5] The few studies that consider the impact of school quality on postschooling productivity, proxied primarily by wages, suggest that the impact of schooling quality may be considerable, with rates of return at least as high as those for investing in school quantity.[6] However, none of these studies traces the links from school quality to cognitive outputs and thence to labor productivity. Nor do they control for preschool ability or for family background, so the estimated returns on school quality and quantity may reflect omitted variable and selectivity biases. A further limitation of most of these studies is that the quality indicators used are highly aggregated and crude, depending on variations across large (regional) groupings of schools in such characteristics as number of teachers per student or average teacher schooling.

In contrast, the data that we use in this study permit investigation of the whole chain that links family background and preschool ability through the quality and quantity of schooling to labor market outcomes, not just part of this chain as in previous studies. Through estimates of education production functions that incorporate measures of school quality as well as years of schooling, ability, and family background variables, we are able to assess the relative impacts on learning outcomes of targeted improvements in schooling quality versus targeted improvements in school quantity for girls and for children in Badin. Estimated earnings functions that incorporate measures of cognitive skill permit us to put a value on these learning outcomes by translating them into earnings gains. By linking these gains to estimates of the costs of additional years of schooling and of improvements in quality, we are able to compare rates of return on alternative targeted investments among four groups of children: boys, girls, children in Faisalabad, and children in Badin. For each group, we calculate the rates of return on (a) enabling a child to complete a low-quality primary school, where previously no school was available, (b) raising the quality of a primary school from low to high, and (c) enabling the graduate of a low-quality primary school to complete middle school. Our principal finding is that targeting the relatively educationally disadvantaged groups (girls in general and children in Badin) involves little, if any, sacrifice in aggregate returns to society in Pakistan.

Importance of School Supply

The gaps in primary school enrollment rates documented in column 1 of table 8-1 are associated in large part with differences in school availability among the four groups of children.[7] The third column of table 8-1 reveals the substantial gender and regional gaps in the availability of a local primary school in rural Pakistan. Limiting the

Table 8-2. Decomposing Gaps in Cognitive Skills for the 20–24 Cohort
(percentage)

Indicator	Gender gap[a]	Regional gap[b]
Net predicted gap[c]	68	72
Equating supply of primary school	36	41
Equating demand and supply for some schooling	5	22

a. (Boys − Girls) / Boys.
b. (Faisalabad − Badin) / Faisalabad.
c. The predicted net gap differs from the observed gap because of nonlinearities in the underlying models being estimated.

sample to children for whom a primary school was available narrows the enrollment gap substantially. Conditional on availability, we find that 76 percent of boys and 63 percent of girls start school.[8] For Faisalabad and Badin, the comparable percentages are 80 and 60. Alderman and others (forthcoming, 1995) and Khan, Ross, and Sabot (1992) conclude that these differences in school availability account for a substantial portion of the observed gender and regional gaps in cognitive skills in rural Pakistan.

Table 8-2 summarizes the results of two counterfactual exercises in these studies to decompose the gender and regional gaps into supply and demand components.[9] Had girls and boys had equal access (at the boys' access level) to primary school, and children in Badin the same access to primary school as children in Faisalabad (at the Faisalabad access level), then the gender and regional gaps would have been reduced by more than 40 percent in both cases (from 68 to 36 percent for gender and from 72 to 41 percent for region). Equating demand for some schooling (at least one year of primary school) for girls and boys virtually eliminates the remaining gender gap in cognitive skills, reducing it from 36 to 5 percent. In contrast, equating demand for schooling in Faisalabad and Badin does not eliminate so much of the remaining regional gap in cognitive skills; a gap of 22 percent still remains. In part, this remaining gap reflects differences between regions in parental inputs into the education process and regional differences in how far children who begin school progress in the schooling system. However, a substantial portion of this gap is likely to reflect differences between these two regions in school quality.

Conceptual Framework

In our framework, both the quantity and the quality of schooling received are presumed to be determinants of a child's cognitive achievement, which in turn is presumed to be a determinant of that child's

subsequent productivity and earnings, as proxied by annual earnings in paid labor markets.[10] Thus our system of relations includes a cognitive achievement production function (equation 8-1) conditional on the quality of local schools and schooling attainment (equation 8-2); an earnings function dependent in part on cognitive achievement, rather than, as in a conventional Mincerian earnings function, on years of schooling (equation 8-3); and an incremental schooling cost function (equation 8-4). Each of these relations explicitly includes gender and region since we focus on these characteristics in this study and the relations may vary with gender or region.

(8-1) $CA = CA(G,PSA,F,A,QS,SA,R),$

(8-2) $SA = SA(G,PSA,F,A,P,QS,R,SAV),$

(8-3) $E = E(G,CA,EX,R),$

(8-4) $SC = SC(G,SA,QS,R)$

where

A = age

E = earnings

EX = earnings experience (that is, time spent in the paid labor force or time since finishing school)

F = a vector of family background characteristics including parental education and household income

CA = cognitive achievement

G = gender

P = a vector of prices including school fees, transportation costs, and costs of books and other supplies for schooling

PSA = preschool ability

QS = a vector of quality characteristics of schools attended

SA = schooling attainment

SC = school costs

SAV = school availability in the local area

R = region.

To isolate the independent effects of quality and quantity (attainment) on cognitive achievement and to avoid omitted variable bias, the production function 8-1 includes indicators of both, as well as such other determinants of achievement as preschool ability and, as a proxy for out-of-school investments in human capital, family background.

Because schooling attainment and cognitive achievement are simultaneously determined, relations 8-1 and 8-2 must be estimated simultaneously. Estimates of relations 8-1 and 8-2 permit an assessment of the importance of school supply-side factors in determining schooling success, with school quality working through both of these relations and local school availability working directly through the latter.

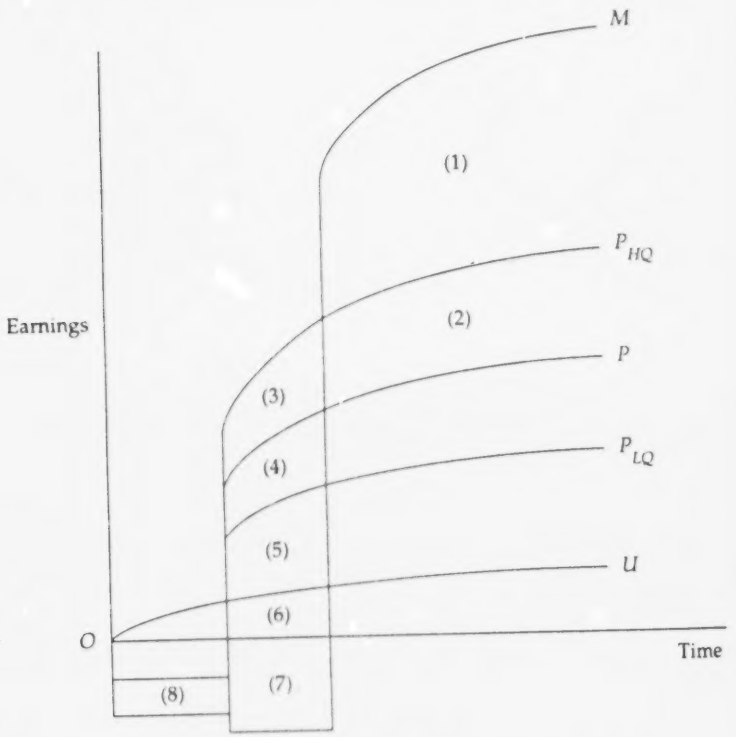
Using estimates of relations 8-1 and 8-3, we also can trace the effects on boys and girls and on children from different regions of, alternatively, improvements in quality and increases in quantity (attainment) on cognitive achievement and thence earnings.[11] Relation 8-4 provides a measure of the incremental costs of these improvements. We are therefore able to calculate and to compare the rates of return for these alternatives. All of these estimates may reflect differences by gender and by region, either with regard to the parameters or with regard to the levels of right-side variables.

For the relevant time period in rural Pakistan, almost all schools were public. Primary school (generally kindergarten plus five grades) is followed by middle school (grades six to eight), and our analysis below focuses on these two school levels since relatively few individuals continue beyond them.[12] Virtually all students attend primary and middle school in their village or in a nearby village or town. The availability and quality of local schools appear to be determined by district and higher-level decisions, perhaps in response to the wishes of politically powerful individuals such as landlords and military officers, but not in direct response to household demand, though village population and proximity to towns and cities both are positively related to schooling quality and quantity. Therefore, we consider the availability and the quality of locally available schools to be given from the point of view of individual households.[13] Our estimation of the cognitive achievement production function in relation 8-1 is thus conditional on the quality of schools attended by respondents.[14]

The rate of return on a given investment in education is defined as that rate of interest that equalizes the present value of the benefits and the costs of that investment. Figure 8-1 illustrates how we calculate the rates of return (a) on investing in middle schooling for a graduate of an average-quality primary school and (b) on augmenting the quality of primary schooling. $O-U$, $O-P_{LQ}$, $O-P$, $O-P_{HQ}$, and $O-M$ represent the lifetime earnings profiles of, respectively, uneducated workers, graduates from low-, average-, and high-quality primary schools, and graduates from middle schools.[15]

Comparing these profiles during the period in which all these groups are economically active, $O-P$ lies above $O-U$ because workers with five years of primary schooling are presumed to have more productivity-augmenting cognitive skills than uneducated workers. Similarly workers with middle schooling are presumed to have more cognitive skills

Figure 8-1. Social Returns on High-Quality Primary Schooling Compared with Returns on Middle Schooling



than workers with only average-quality primary schooling, and so $O-M$ lies above $O-P$. Likewise, $O-P_{HQ}$ lies above $O-P$ because workers who attended high-quality primary schools are presumed to have greater cognitive skills than workers who attended average-quality primary schools. The area 1 + 2 thus signifies the gross returns on middle school for the graduate of an average-quality primary school who otherwise would enter the labor market, and the area 2 + 3 signifies the gross returns on high-quality primary school for a student who otherwise would attend an average-quality primary school.

The area 4 + 5 + 6 signifies the opportunity cost of attending middle school, while area 7 represents the direct costs. Since our concern is with policy choices between increasing quantity and improving quality for girls and for children in Badin, our focus is on social and not on

private rates of return. Therefore, the direct costs include both those borne by the household and those borne by the government. Area 8 represents the incremental expenditures necessary to transform an average-quality primary school into a high-quality primary school. To estimate rates of return on improving quality and to increasing quantity, we require measures of each of these various components of benefits and costs.

Our presumption is that a student who attends an improved quality primary school would not have been in the labor market but rather would have attended an average-quality primary school, so there is no opportunity cost associated with investing in quality improvement for such students.[16] The opportunity costs of investment in education are often a substantial proportion of total costs, so their absence (or limited role) in this case is likely to have an important influence on the rate of return on improving quality relative to the rate of return on increasing quantity.

Data

Since 1986, the International Food Policy Research Institute (IFPRI), under the auspices of the Pakistan Ministry of Food and Agriculture, has been administering a multipurpose survey to a panel of 800+ rural households containing more than 7,000 individuals drawn from villages in three relatively poor districts—Attock in the Punjab, Dir in the North West Frontier Province, and Badin in the Sind—and one relatively prosperous district—Faisalabad in the Punjab (the only province not represented, Baluchistan, has a small proportion of the rural population). The households have been interviewed approximately four times each year. Human capital modules, on which we draw heavily for this study, were administered in the spring of 1989, the tenth round of the survey. These modules contain, inter alia, measures for individual respondents of the variables needed to estimate our model: that is, family background, school availability, educational attainment, preschool reasoning ability, and postschooling cognitive achievement. A questionnaire designed to yield indicators of school quality also was administered to teachers in the schools attended by sample members.

Our analysis focuses on the 637 respondents between ages ten and twenty-five who had an opportunity to attend one of our sample schools and for whom all variable values were available.[17] Of these, 244 respondents completed at least four years and had nonmissing values for the variables needed to estimate cognitive skills production functions. Descriptive statistics for the measures of particular importance in this study appear in table 8-3 and are discussed below. The greater representation of boys than girls and of respondents from

Table 8-3. Sample Means and Standard Deviations for Cognitive Achievement Production Functions

Characteristic	Selectivity estimation					Production function				
	Full	*Boys*	*Girls*	*Faisalabad*	*Badin*	*Full*	*Boys*	*Girls*	*Faisalabad*	*Badin*
Individual, family, and other characteristics										
Reading score						13.29	13.02	14.05	14.34	11.86
						(7.02)	(6.94)	(7.27)	(7.44)	(7.31)
Math score						11.62	12.29	9.70	14.08	7.24
						(6.70)	(6.67)	(6.47)	(7.01)	(5.10)
Schooling attainment	4.08	4.60	3.06	4.67	2.03	7.28	7.61	6.33	7.61	6.29
	(3.51)	(3.66)	(2.94)	(3.39)	(2.91)	(2.32)	(2.33)	(2.01)	(2.38)	(1.71)
Preschool ability	19.41	20.88	16.56	19.23	18.29	22.70	24.03	18.87	22.82	22.05
	(6.85)	(6.98)	(5.59)	(6.70)	(6.97)	7.17	(6.86)	(6.72)	(6.91)	(8.75)
Family income	24.19	24.39	23.80	23.23	21.75	25.52	26.06	23.96	25.08	25.54
	(8.71)	(9.39)	(7.24)	(7.82)	(10.79)	(8.95)	(9.41)	(7.34)	(9.18)	(11.30)
Mother primary or more (percentage)	5.8	5.7	6.0	9.3	0.0	10.7	9.9	12.7	16.8	0.0
Father middle or more (percentage)	20.3	15.2	30.0	26.2	4.5	30.7	23.2	52.4	35.2	4.8
Primary book cost proxy	55.45	55.83	54.71	64.61	56.99	53.37	54.16	51.09	64.51	55.82
	(19.54)	(18.42)	(21.56)	(16.67)	(11.94)	(19.41)	(19.01)	(20.52)	(13.55)	(10.50)
Middle book cost proxy	215.60	217.12	212.68	253.38	169.05	215.62	222.62	195.51	237.32	189.53
	(74.44)	(67.89)	(85.81)	(46.52)	(97.83)	(68.90)	(57.52)	(91.89)	(64.00)	(81.39)
Middle school available (percentage)	92.0	93.1	88.0	98.3	75.3	94.7	97.8	85.7	97.8	85.7
School characteristics										
Student/teacher ratio	56.27	64.78	39.79	52.82	65.40	57.60	63.08	41.86	53.19	75.70
	(36.74)	(41.41)	(15.28)	(21.62)	(20.76)	(37.90)	(41.77)	(14.99)	(22.58)	(24.76)
Average teacher reading score	19.38	18.86	20.39	20.11	21.75	19.66	19.32	20.65	20.21	23.24
	(4.89)	(5.64)	(2.67)	(3.81)	(3.06)	(5.20)	(5.69)	(3.27)	(4.04)	(2.39)
Average teacher math score	17.39	18.41	15.42	18.52	17.39	18.00	19.63	13.34	20.11	18.64
	(7.48)	(6.74)	(8.41)	(7.28)	(2.77)	(7.94)	(7.32)	(7.83)	(7.52)	(2.66)
Average teacher experience	9.98	10.78	8.42	9.53	9.70	10.21	10.69	8.84	10.67	8.85
	(4.36)	(4.62)	(3.32)	(5.21)	(2.04)	(4.51)	(4.81)	(3.14)	(5.36)	(2.33)
Average teacher schooling	3.30	3.24	3.42	3.28	4.10	3.26	3.24	3.34	3.33	4.35
	(0.69)	(0.74)	(0.57)	(0.38)	(0.62)	(0.60)	(0.64)	(0.48)	(0.40)	(0.60)
Teacher reading quality index						2.70	2.70	2.71	2.90	3.30
						(0.84)	(0.92)	(0.56)	(0.97)	(0.51)
Teacher math quality index						1.69	1.80	1.46	1.81	1.63
						(0.67)	(0.71)	(0.47)	(0.81)	(0.30)
N	637	420	217	301	89	244	181	63	125	21

Note: Standard deviations are in parentheses.

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Faisalabad than from Badin reflects in part the differences in school availability described above.

Cognitive Achievement

Our measure of cognitive skills was generated by administering (in the regional language) to every person in our sample more than ten years old, and with at least four years of schooling, tests of literacy and numeracy especially designed by the Educational Testing Service.[18] The distribution of the cognitive skills test scores is not truncated, exhibits substantial variance, and appears to be normally distributed, all of which suggests that the tests were appropriate for the population sampled. Because school quality affects scores on our literacy and numeracy tests differently, we report separate production function estimates using the reading and mathematics scores. The sample means suggest that when girls are permitted to progress through the school system, their cognitive achievement compares well with that of boys who have greater access. Girls completing at least four years of schooling score significantly below boys in mathematics but exceed boys on the literacy test. In contrast, children from Badin who progressed through the school system still lag in cognitive achievement in mathematics. Respondents from Faisalabad score nearly twice as high on the mathematics test as do respondents from Badin; however, Badin respondents lag only slightly on the reading test.

School Attainment

We report the mean level of schooling completed (no adjustment is made for repetition) for all respondents for whom a school was available (the selectivity estimation columns of table 8-3) and who completed at least four years of school (the production function columns). As the sample sizes suggest, fewer primary schools are available for girls than for boys. Virtually all of the difference in schooling attainment for respondents who started school is associated with differences in the availability of middle school.[19]

Preschool Ability

To obtain a measure of preschool reasoning ability, we administered Raven's (1956) Coloured Progressive Matrices (CPM), a test of reasoning ability that involves the matching of patterns, to everybody in the sample ten years of age or older.[20] The test is designed so that formal schooling does not influence performance, though performance may reflect early childhood environment as well as innate capacity. The distribution of the CPM test scores is not truncated at either tail; it

exhibits substantial variance and appears to be normally distributed. The disaggregated distributions for Dir, the Punjab, and Badin are very similar. Since educational levels differ substantially across regions, this similarity is consistent with the presumption that educational attainment does not influence performance on Raven's CPM test.[21]

Family Background

We summarize family characteristics by indicators of parental schooling and by income (in thousands of rupees). The low level of schooling attainment for parents (in our sample, none of the mothers from Badin had completed primary school) in comparison with the schooling for their children suggests the progress that Pakistan has made in expanding the rural educational system. We use predicted rather than observed household income in relation 8-2. In much of agriculture in developing countries, transitory income fluctuations may be considerable because of weather shocks and limited mechanisms to buffer such shocks. If longer-run income measures determine investments such as schooling, the extent of income variance in the annual data may be misleading regarding the effective income spreads for the analysis of the determinants of cognitive achievement. Similarly, if current income at the time of the survey is influenced by the productivity of respondents who earlier completed schooling, then it will be a positively biased proxy for income at the time schooling decisions were made. Therefore for our sample we use parents' assets and other characteristics to yield an unbiased measure of permanent family income at the time the respondent was of school age.[22]

Price of Schooling

To explain schooling attainment for students for whom a primary school was available, we require cost indicators. Virtually all boys in all regions and all children in Faisalabad who had a primary school available also had access to a middle school. Girls in all other regions and all children in Badin were less fortunate. Expenditures on books and school supplies are dependent not only on the school system, but also on the household's preferences and income. Consequently, they have endogenous components. To obtain an instrumental variable or proxy for the exogenous cost component, we estimate educational expenditure functions including a vector of household characteristics, dummy variables for district, level of schooling, gender, and whether the school was located in the village or a nearby town. The household variables are then held constant to predict exogenous costs, that is, prices. Because of the high correlation among costs for books, clothing, and other fees, we include only textbook costs in our estimates.

School Characteristics

As noted above, the school survey permits us to identify which schools respondents attended. It also provides measures of a rich array of school characteristics—too many to include individually in the cognitive skills production function. Instead, we use the measures to create indexes summarizing the important dimensions of school quality. The teacher quality in reading index is a linear function of teacher literacy, schooling attainment, teaching experience, and experience squared; the teacher quality in mathematics replaces teacher literacy with teacher numeracy. Coefficients for the variables in the index are estimated jointly with the cognitive skills production function. The ratio of students to teachers serves as an index of student-teacher contact. Attempts to create an index of physical characteristics of schools—using linear functions incorporating, for example, measures of the year in which the school was constructed, textbook availability, the number of classrooms with blackboards and chalk, and desk availability—did not add significant explanatory power to the production function. Weights for the component measures are estimated as part of the cognitive skills production function.

The teacher quality index for reading does not differ significantly by gender (in our sample, girls are taught exclusively by women, boys by men). Teachers in Badin actually have a higher reading index than teachers in Faisalabad. Although there is no significant difference in the teacher quality index for mathematics by region, female teachers have a mathematics index well below that of male instructors. There is much greater variation in student/teacher ratios. The student/teacher ratio for girls (42) is not quite two-thirds that for boys (64).[23]

Estimates

Relations 8-1 (cognitive achievement) and 8-2 (schooling attainment conditional on availability) are estimated simultaneously in Behrman and others (1993) by maximizing the joint likelihood functions for educational attainment and the production of cognitive skills, controlling for the sample truncation resulting from the fact that cognitive achievement at each level is observed only for respondents who did not remain in school beyond that level. Schooling attainment—measured as no schooling, less than fourth grade, fourth or fifth grades, and postprimary—is a linear function of the explanatory variables. The selectivity thresholds indicate movements in the latent schooling attainment variable among levels.[24] Because the level of schooling, the quality of schooling, and the ability of the individual all interact with one another,[25] a multiplicative (Cobb-Douglas) functional form is used for the production function—with gender and regional dummies serving as shifters for the constant. Parameter estimates appear in table 8-4. Counting the exponent, more coefficients than variables are associated with the teacher quality indexes. We arbitrarily normalize the coefficient on the average teacher reading (mathematics) test score to 1. Sigma is the standard error of the production function; rho is the correlation coefficient for the production and attainment function error terms. The Wald statistics allow one to reject the null hypothesis that all but the intercept coefficients are zero at the 1 percent significance level for the entire model and for the production functions.

As the results presented in table 8-4 show, assuming all else is equal, a 10 percent increase in schooling attainment raises reading and mathematics scores by just over 4 percent. A 10 percent increase in the teacher quality indexes raises the predicted reading test score by 3 percent and the mathematics score by 1 percent. Lowering the student/teacher ratio by 10 percent raises the predicted mathematics score by 2 percent. Within the production function, the gender and regional dummies allow for quality differences captured by neither the teacher quality index nor the student/teacher ratio. Thus, even though the *t*-ratio on the student/teacher ratio in the reading production function is insignificant and the regional dummy variables are jointly insignificant (Wald statistic = 3.67), the relevant Wald statistic rejects the null hypothesis that the student/teacher ratio and the regional dummies are jointly insignificant determinants of reading. Apparently, the student/teacher ratio is correlated with school quality characteristics not captured by our model.

Holding all other factors constant, there is no evidence that girls or children from Badin are at a disadvantage in mastering reading skills. The coefficients on the regional dichotomous variables suggest that children from Badin are at a significant disadvantage relative to children from Faisalabad in mastering numeracy, even after controlling for all the other variables in our model. There may also be uncaptured factors that place girls at a disadvantage when mastering mathematics skills, although the coefficient on the 0/1 female dummy variable is insignificantly different from zero.

Of course, the other explanatory variables in these relations vary by region and gender. These variations must be taken into account in decomposing variations in cognitive achievement. Based on our cognitive achievement production function estimates (table 8-4)[26] and the sample means (from table 8-3), we derive the predicted cognitive achievement scores for boys and girls and for children of both sexes from Faisalabad and from Badin for our three schooling investment alternatives (holding all other characteristics at their sample means).

Thus, we predict (in table 8-5) cognitive skills after five years (completed primary) of low-quality primary school, five years of high-quality primary, and eight years of schooling (completed middle

Table 8-4. Cognitive Achievement Production Function Estimates

Indicator	Reading		Mathematics	
	Production	Selection	Production	Selection
Female	0.41	−0.72	−0.26	−0.76
	(2.09)	(4.96)	(1.08)	(5.42)
Faisalabad	0.19	1.69	0.92	1.67
	(1.36)	(4.60)	(3.68)	(5.00)
Dir	−0.27	−2.54	0.065	−2.51
	(0.78)	(5.66)	(0.18)	(3.88)
Badin	0.079	−1.23	−0.50	−1.31
	(0.27)	(5.68)	(1.24)	(5.19)
Preschool ability	0.34	0.051	0.42	0.052
	(3.18)	(5.92)	(2.43)	(5.86)
Schooling level	0.42	n.a.	0.41	n.a.
	(4.07)		(3.65)	
Student/teacher ratio	−0.058	−0.0001	−0.16	−0.0001
	(0.80)	(0.06)	(2.71)	(0.09)
Teacher quality	0.29	n.a.	0.10	n.a.
	(2.12)		(2.99)	
Reading/math score	1.00	0.015	1.00	−0.012
			(1.12)	(1.36)
Schooling level	2.36	0.029	1.66	0.14
	(1.04)	(0.28)	(0.45)	(1.11)
Experience	−0.16	0.014	0.01	0.011
	(0.41)	(1.01)	(0.21)	(0.63)
Experience squared	0.024	n.a.	0.15	n.a.
	(0.58)		(1.56)	
Father middle or more	n.a.	0.54	n.a.	0.49
		(3.20)		(3.36)
Family income	n.a.	0.030	n.a.	0.030
		(4.64)		(3.64)
Primary book cost proxy	n.a.	−0.012	n.a.	−0.013
		(4.12)		(3.08)
Middle book cost proxy	n.a.	−0.036	n.a.	-0.034
		(3.92)		(3.65)
Middle school available	n.a.	−8.09	n.a.	−7.76
		(4.03)		(3.49)
Production function constant	1.90	n.a.	2.19	n.a.
Selectivity threshold 1	n.a.	−7.67	n.a.	−7.56
Selectivity threshold 2	n.a.	−7.40	n.a.	−7.30
Selectivity threshold 3	n.a.	−6.58	n.a.	−6.48
Sigma	n.a.	5.44	n.a.	5.56
		(18.37)		(21.27)
Rho	n.a.	−0.008	n.a.	0.182
		(0.05)		(1.04)
Wald statistic (df)	53.02 (11)	257.78 (25)	62.52 (11)	247.31 (25)
N	244	637	244	637

n.a. Not applicable.
Note: Numbers in parentheses are *t*-ratios.

Table 8-5. Predicted Cognitive Skills at Sample Means

Skill	Boys	Girls	Faisalabad	Badin
Reading				
Low-quality primary	10.6	12.5	11.9	11.4
High-quality primary	12.2	13.5	12.9	12.1
Average middle	12.9	15.2	14.5	13.8
Mathematics				
Low-quality primary	9.4	8.2	11.0	5.7
High-quality primary	10.9	9.0	11.5	6.1
Average middle	11.4	10.0	13.4	6.9
Cognitive skills				
Low-quality primary	20.0	20.7	22.9	19.8
High-quality primary	23.1	22.5	24.4	21.2
Average middle	24.3	25.1	27.8	24.1

school), including five years at a low-quality primary school. A low-quality primary school is defined to be one with all quality measures set to one-half standard deviation below the mean for each group.[27] Under all three scenarios, girls perform better than boys in reading. This is consistent with the superior performance of women on the reading test reported in table 8-3 and suggests that the gender gap in literacy in rural Pakistan is a function of lower schooling attainment by women—not quality differences in schools. There is no significant regional difference in predicted reading scores. However, the model predicts lower levels of numeracy for girls and for all children from Badin.

The impact of quality differences on cognitive achievement is substantial relative to the effect of increasing schooling attainment. Raising the quality of primary schools in Badin raises cognitive skills by 1.4 points (21.2 − 19.8), or 32 percent of the gain a student from a low-quality primary school would realize from completing middle school. For girls, the gain in cognitive skills from raising primary school quality is 41 percent of the gain from completing middle school.

To measure the value of these variations in cognitive skills, we rely on estimates of the monthly wage labor earnings function provided by Alderman and others (forthcoming, 1996). We summarize their results briefly here. The wage labor market is still quite small in rural Pakistan.[28] Of 2,285 respondents for whom nonmissing values of all relevant variables were available, 207 were engaged in wage labor (table 8-6 provides descriptive statistics). These workers move back and forth between wage employment and (primarily) own-farm agricultural work. As a result, current wage workers have spent just over half of their working careers in wage jobs.

Table 8-7 provides maximum likelihood parameter estimates of the earnings function with controls for self-selection into wage employ-

Table 8-6. Sample Means and Standard Deviations for Earnings Function

Characteristic	All adults	Wage workers
Individual characteristics		
Wage worker	0.09	n.a.
Log (wage)	n.a.	6.74
		(0.64)
Female	0.53	0.06
Attock	0.20	0.32
Faisalabad	0.19	0.22
Dir	0.22	0.18
Badin	0.39	0.28
Total experience	19.77	19.11
	(17.25)	(13.85)
Wage labor experience proxy	0.32	11.85
	(1.61)	(3.63)
Cognitive skills proxy	4.06	12.29
	(10.18)	(14.23)
Body-mass index proxy	0.19	0.21
	(0.01)	(0.01)
Father was a wage worker	0.14	0.18
Household characteristics		
Distance to work proxy	19.68	16.97
	(10.80)	(20.72)
Males over 16	3.25	3.07
	(1.79)	(1.55)
Net transfers	5,180.48	4,146.06
	(15,456.56)	(14,618.69)
Rain-fed acres	2.72	2.94
	(9.49)	(10.98)
Irrigated acres	6.09	2.27
	(15.07)	(6.16)
N	2,285	207

n.a. Not applicable.
Note: Standard deviations are in parentheses.

ment.[29] All else remaining equal, women are much less likely to enter wage employment than men; however, the estimates suggest no significant regional variation in the probability of wage employment, controlling for other determinants.[30] Respondents are more likely to have wage employment if they are younger,[31] have higher cognitive skills, live closer to the location of wage jobs, or live in households farming smaller plots.

For those employed, the log of monthly earnings is regressed on cognitive skills, health status, wage labor market experience, as well as gender and regional dummies. Because cognitive skills, health status (body mass index, BMI), and years of wage labor experience are likely to be correlated with unobserved determinants of wages, Alderman and others (forthcoming, 1996) derive proxy instrumental variables.[32]

Table 8-7. Wage Function Estimates, Controlling for Selectivity

Characteristic	Log (wage) function	Selectivity controls
Female	−0.248	−0.952
	(0.68)	(3.93)
Faisalabad	−0.394	−0.129
	(2.47)	(0.60)
Dir	−0.304	−0.303
	(1.79)	(1.36)
Badin	0.072	−0.144
	(0.52)	(0.85)
Cognitive skills proxy	0.012	0.019
	(7.07)	(2.45)
Wage proxy for educated labor experience	0.035	−0.006
	(1.70)	(0.24)
BMI proxy	18.15	28.27
	(1.20)	(2.86)
Years of schooling proxy		0.027
		(1.25)
Preschool ability		0.015
		(1.51)
Total experience		−0.011
		(2.32)
Father was a wage worker		0.420
		(2.88)
Distance to work proxy		−0.011
		(3.99)
Males over 16		−0.075
		(2.52)
Net transfers		0.000
		(1.43)
Rain-fed acres		
Attock		−0.012
		(1.91)
Dir		−0.083
		(1.71)
Irrigated acres		
Attock		−0.054
		(0.26)
Faisalabad		−0.125
		(3.34)
Dir		−0.078
		(0.91)
Badin		−0.013
		(1.39)
Constant	2.64	−6.20
Sigma		0.602
		(11.50)
Rho		0.369
		(1.27)
Wald statistic (df)	44.9 (7)	157.7 (27)
N	207	2,285

Note: Numbers in parentheses are *t*-ratios.

Table 8-8. Selected School Costs as a Function of School Quality

Characteristic	Public expenditures		Distance to school (time)	
	(1)	(2)	Boys	Girls
Teacher reading quality index	8.62	3.71	−8.22	−1.31
	(2.40)	(1.92)	(5.95)	(0.76)
Teacher math quality index	−0.75	0.14	0.18	−0.48
	(1.32)	(0.47)	(2.85)	(2.26)
Student/teacher ratio	−0.59	−0.036	−0.10	−0.061
	(5.75)	(0.56)	(2.75)	(2.27)
Female	1.08	−3.40	n.a.	n.a.
	(0.11)	(0.62)		
Attock	n.a.	14.95	−2.45	−11.72
		(1.42)	(0.42)	(2.42)
Faisalabad	1.69	−2.22	−4.61	−14.09
	(0.16)	(0.40)	(0.79)	(3.19)
Dir	21.96	−0.42	10.87	−18.31
	(2.43)	(0.09)	(1.33)	(3.16)
Constant	44.64	−7.80	35.91	41.63
Adjusted R^2	0.394	0.026	0.249	0.097
F (probability)	7.86	1.28	8.62	3.46
	(0.001)	(0.27)	(0.001)	(0.003)
N	75	75	139	200

n.a. Not applicable.

Note: Numbers in parentheses are t-ratios. Figures in column (1) refer to monthly teacher salaries per pupil; column (2) figures are for the annual recurring nonsalary expenses per pupil.

They found no evidence that years of schooling or preschool ability has any effect on wages independent of cognitive achievement; that is, they found no evidence of credentialism or screening effects. Wage labor experience affects wages only for respondents who have completed primary school. The coefficients on the female dummy variable and the body mass index instrumental variable are jointly significant (Wald statistic = 9.27), suggesting that, all else remaining equal, the logarithm of the monthly wage for women is −0.42 less than that for men.[33] Wages in Faisalabad are significantly lower than wages in Badin (the finding of lower wages in Faisalabad is consistent with results reported by Kozel and Alderman 1990 for an urban sample). Alderman and others (forthcoming, 1996) find that the regional variations are a function of differences in the occupational composition of the work force. Highly paid supervisory positions are relatively more common among respondents from Badin, lower-paying semiskilled positions are relatively more common among respondents from Faisalabad. Occupational status is in part a function of cognitive skills. To the extent that regional dummy variables and cognitive skills are each correlated with occupational status, the coefficients on the regional dummy variables are capturing some of the effect of cognitive skills on wages. This has the effect of biasing the coefficient on cognitive skills down somewhat.

The last component required for a rate-of-return comparison is the calculation of school costs. Behrman and others (1993) found that per student teacher pay varies with measures of school quality, but that nonsalary recurring expenditure does not. Their results appear as columns 1 and 2 in table 8-8.[34] Using these results, we calculate the public expenditures per pupil at each school quality level (columns 1 and 2 of table 8-9; expenditure estimates not based on table 8-8 are sample means). Note that the provision of even low-quality primary education for girls is relatively expensive—largely because of the high level of student-teacher contact that prevails at girls' schools.

We found no evidence that private out-of-pocket expenditures on books, clothing, and school fees vary with our quality measures. However, we did find that the distance students travel to school does vary with quality and in a different fashion for boys and girls (we found no evidence that out-of-pocket expenditures vary by gender). The last two columns of table 8-8 provide those regression estimates. Students who travel a longer distance tend to have smaller classes. A longer commute gives boys higher-quality mathematics instruction, but lower-quality reading instruction. The longer commute gives girls *lower*-quality mathematics instruction. To translate variations in commuting time into dollar costs, we use estimates of the determinants of the demand for schooling in Alderman, Ross, and Sabot (1991).[35]

The final dimension needed to calculate the costs of alternative schooling options is the opportunity cost of schooling. We do not have

Table 8-9. Schooling Costs, by Gender and Region
(rupees per year)

Gender and region	Teacher salary per pupil	Recurring nonsalary expense per pupil	Private out-of-pocket expenses	Opportunity cost of schooling at age 15
Boys				
No school	0.0	0.0	0.0	6,589.8
Low-quality primary	198.1	2.8	282.1	8,376.2
High-quality primary	444.7	2.8	280.9	8,693.9
Average middle	516.1	34.0	631.6	n.a.
Girls				
No school	0.0	0.0	0.0	3,346.9
Low-quality primary	508.5	7.5	310.6	4,289.9
High-quality primary	583.5	7.5	303.7	4,385.2
Average middle	1,073.2	56.6	634.9	n.a.
Faisalabad				
No school	0.0	0.0	0.0	5,784.3
Low-quality primary	190.2	3.3	282.2	7,616.6
High-quality primary	356.8	3.3	280.4	7,753.3
Average middle	999.5	34.2	929.4	n.a.
Badin				
No school	0.0	0.0	0.0	6,997.3
Low-quality primary	213.2	0.16	279.8	8,583.8
High-quality primary	367.4	0.16	279.2	8,705.1
Average middle	604.1	14.4	351.2	n.a.

n.a. Not applicable.

estimates of the value of production within the household or on the family farm, and our wage labor sample includes few observations for school-age children. On the assumption that rural Pakistanis not in school typically enter the wage labor market at age fifteen, we use the estimated wage of a respondent with no experience as a measure of the opportunity cost of schooling for a fifteen year old.[36] To bracket the opportunity cost of younger children in our subsequent calculations, we use two extreme bounds. First, we assume zero opportunity cost for children fourteen and younger. Second, we assume that there is zero opportunity cost to attending the first grade, but that the opportunity cost rises linearly until it reaches the market wage at age fifteen.

The bracketing is important because, as table 8-9 indicates, opportunity costs are potentially the dominant cost of schooling. Column 1 presents estimates of the annual teacher salaries per pupil in rupees. The higher costs for girls reflect a lower student/teacher ratio and the lower variance in that ratio between high- and low-quality primary schools. Column 2 reports the much lower charge for recurring nonsalary expenses per pupil. Column 3 presents out-of-pocket annual household expenditures per student. There is little variation in these expenditures by region and gender. The variation in private expenditures between high- and low-quality primary schools reflects the small savings from the shorter commute (on average) to high-quality schools observed in our sample. Column 4 reports the opportunity cost of attending a year of school at age fifteen for a child with no previous schooling, with five years of low-quality primary school, and with five years of high-quality primary school. Gender and regional differences reflect the impact of the gender and regional dummy variables in the wage equation, which as noted above reflect differences in the occupational composition of our sample.[37] Within each gender and region category, the opportunity cost reflects the impact on the logarithm of monthly wage earnings of the cognitive skills obtained in low- and high-quality primary schools.

We turn now to the calculation of the private and social rates of return on various schooling investments. The benefits of improving the quality and quantity of schooling are represented by the discounted present values of the resulting increases in postschooling lifetime (four decades) earnings. We perform the following simulation exercise. A student enters primary school at age eight and attends school for five years. The student achieves a particular level of cognitive skills at a particular annual cost depending on whether the student (a) attended an average low-quality primary school or (b) an average high-quality primary school. If the student leaves after primary school (at age thirteen), the student enters productive work at age fifteen and works until age sixty.[38] As a third option, we explore what happens if a student attends three years of an average-quality middle school after attending

Table 8-10. Rates of Return on Alternative Schooling Investments
(percent)

Gender, region, and level of schooling	Social (1)	Social (2)	Private (1)	Private (2)
Boys				
Low-quality primary vs. no school	33.0	19.2	40.7	20.3
Middle school after low-quality primary	5.7	2.2	6.6	2.4
High- vs. low-quality primary	16.8	19.1	n.a.	n.a.
Girls				
Low-quality primary vs. no school	20.0	15.4	30.3	18.8
Middle school after low-quality primary	3.6	1.4	5.8	2.3
High- vs. low-quality primary	17.5	20.0	n.a.	n.a.
Faisalabad				
Low-quality primary vs. no school	33.0	20.0	40.5	21.3
Middle school after low-quality primary	5.2	2.3	6.7	2.8
High- vs. low-quality primary	13.1	14.5	n.a.	n.a.
Badin				
Low-quality primary vs. no school	31.9	18.1	39.7	18.4
Middle school after low-quality primary	5.2	1.7	6.2	2.0
High- vs. low-quality primary	12.7	14.0	n.a.	n.a.

n.a. Not applicable.

Note: (1) Assuming the opportunity cost of attending school is limited to age fifteen; (2) assuming a linear extrapolation of the age fifteen opportunity cost for younger children.

an average low-quality primary school. That student starts productive work at age sixteen and works for forty-four years.

Table 8-10 reports social and private returns for the three targeting alternatives for boys, girls, children in Faisalabad, and children in Badin under our two bounding opportunity cost assumptions.[39] The rates of return on the provision of middle- and low-quality primary school do not incorporate capital costs. The rates of return on improving quality are understated to the extent that improvements in quality reduce repetition rates and hence recurrent costs.[40] All rates of return are understated to the extent that social benefits exceed private benefits or to the extent that there are private benefits (for example, better health and nutrition, better information processing capacities for purchases, and greater efficiency in household production) that are not included in these calculations. The only benefits to education included in the analysis are increased earnings, which are assumed to reflect directly economic productivity, narrowly defined.

The social rates of return on the provision of even a low-quality primary school for all four groups are high—between 15 and 33 percent, depending on the treatment of opportunity costs. The high returns on improving quality reflect the absence of any opportunity cost to the students and the absence of higher capital costs for students already enrolled in school. For the purposes of this chapter, the key finding is

that rates of return from targeting the educationally disadvantaged groups are high. The return on improving the quality of a low-quality primary school in Badin is comparable to that in Faisalabad for each of the four calculations. The return on improving the quality of primary schools is slightly higher for girls than for boys, reflecting the lower cost of a smaller adjustment in class size for girls. Although the returns on investing in a low-quality primary school for girls are lower than those for boys, they are high relative to those in noneducational marginal investments.[41] Expanding the number of middle schools has the lowest return of the three alternatives. The implication is that targeting girls in all regions or all children in Badin would not involve a substantial efficiency trade-off relative to investing in middle schools for boys or children in Faisalabad.

Conclusions

Schooling is distributed unequally by gender and by region in many developing countries. As a result, the gains from schooling also are distributed unequally. In this chapter, we investigate the consequences of targeting to improve the schooling attainment of two disadvantaged groups, defined by gender (girls) and by region (Badin), in rural Pakistan using an unusually rich micro data set. We address three major points.

First, supply-side factors appear to be important in determining the level and the distribution of schooling performance in rural Pakistan. Our results suggest that, in addition to household demand considerations, both the availability of local schooling and the quality of those schools are significant factors in understanding the observed patterns, including the gender and regional gaps: 40 percent or more of gender and regional gaps in cognitive achievement are associated with gender and regional gaps in local school availability. Thus it would appear that there is leverage for targeted policies to operate through school supply to improve the distribution of the benefits of schooling.

Second, the rates of return on investments in school quantity and quality for all girls and for all children in Badin are high and, for the most part, comparable to the returns on corresponding investments for boys and children in Faisalabad. Making even low-quality primary schools available has the highest return for all groups except girls under our high-bound estimates of opportunity costs. In all cases, raising the quality of primary schools has a substantially higher rate of return than expanding the availability of middle schools.

Third, the estimated social rates of return on targeted schooling investments that expand the quantity of even low-quality primary schools and that improve the quality of primary schools are fairly high regardless of gender and region in rural Pakistan. Therefore targeting

investments in schooling in rural Pakistan in order to reduce educational inequities would not have high opportunity costs in terms of forgoing other much more productive investments. Thus equity can be increased without sacrificing much in the way of productivity.

Computational Appendix 8-1

The equations in table 8-8 are ordinary least squares regressions estimated using the SAS computer package REGRESSION procedure. The equations in tables 8-4 and 8-7 use the MAXLIK applications module to the GAUSS computer package.

The production function estimated in columns 1 and 3 of table 8-4 regresses the mathematics or reading score on

$$(\alpha_0 + \alpha_1\text{Female} + \alpha_2\text{Faisalabad} + \alpha_3\text{Dir} + \alpha_4\text{Badin}) \times (\text{Preschool Ability})^{\beta 1} \times (\text{Schooling Attainment})^{\beta 2} \times (\text{Student/Teacher Ratio})^{\beta 3} \times (\text{Teacher Quality})^{\beta 4} + \epsilon;$$

$$\text{Teacher Quality} = (\gamma_0\text{Mathematics/Reading} + \gamma_1\text{Schooling Attainment} + \gamma_2\text{Experience} + \gamma_3\text{Experience}^2),$$

where the αs, βs, and γs are parameters to be estimated and ε is an error term.[42] Counting the exponent, more coefficients than variables are associated with the teacher quality indexes. We normalize the equation arbitrarily by setting $\gamma_0 = 1$.

To control for the simultaneous determination of schooling attainment, we start by assuming that a latent continuous schooling attainment index is a linear function of the variables in columns 2 and 4 of table 8-4 and a normally distributed error term ν. Schooling attainment is observed as no schooling, less than fourth grade, fourth or fifth grades, and postprimary.[43] Let τ_1 be the threshold parameter for the transition from no schooling to less than fourth grade; τ_2 be the parameter for the transition from less than fourth grade to grades four or five; and τ_3 be the parameter for the transition from fourth or fifth grades to postprimary schooling. The probability that a particular respondent who has completed his or her schooling will be observed as completing grades four or five is the probability that the predicted value of the latent schooling attainment function plus ν lies between τ_2 and τ_3. This is the standard ordered probit model. However, our sample contains a number of students still in school, for whom we do not observe final schooling attainment. The probability that a particular respondent who is still in school will be observed in grades four or five is the probability that the predicted value of the latent schooling attainment function plus ν exceeds τ_2.

We obtain estimates of the coefficients of the cognitive skills and schooling attainment functions by maximizing the bivariate normal likelihood functions for ε and ν. Sigma is the standard error of the production function; rho is the correlation coefficient for the production and attainment function error terms.

The earnings function presented in table 8-7 defines the logarithm of monthly earnings to be a linear function of the variables listed in column 1 and an error term. The sample is truncated, in that we observe wages only for respondents currently engaged in wage work. To control for the resulting sample selection bias, we start by assuming there is some latent index of the value of wage work to the respondent, which is a linear function of the variables in column 2 plus an error term. The probability that a respondent is engaged in wage work is the probability that the expected value of the latent value index plus the error term exceeds a threshold parameter, arbitrarily set to zero.

Notes

1. See, for example, Behrman (1990a, 1990b, 1990c); Birdsall and Sabot (1993); Colclough (1982); Eisemon (1988); Haddad and others (1990); King (1990); King and Hill (1993); Knight and Sabot (1990); Psacharopoulos (1985, 1988); Schultz (1988, 1993); UNDP (1990); and World Bank (1980, 1981, 1990, 1991).

2. The gender distinction is easier to measure in Pakistan than in many countries because of the prevalence of single-sex schools.

3. The schooling enrollment and availability data are taken from Alderman, Ross, and Sabot (1991); the cognitive achievement data by gender from Alderman and others (forthcoming, 1995); the data by region from Khan, Ross, and Sabot (1992). The gender gaps in enrollment rates and primary school availability are consistent with data drawn from the Pakistan Integrated Household Survey, a nationally representative sample for 1990–91 (Sather and Lloyd 1993). Large gender gaps in schooling and other human resources in Pakistan on an aggregate level in comparison with other countries with more or less the same real gross domestic product per capita are reported in Behrman and Schneider (1993). Other characteristics, such as low income, also may be of interest for targeting. As is often the case, and is certainly true for rural Pakistan, however, regional differences are correlated with a large fraction of variations in income. Therefore we concentrate on gender and region in this study and leave questions about possible targeting by income to other analyses.

4. In human capital models, it is the output of schooling—cognitive and other skills—not such inputs to educational production as years of schooling, that is presumed to affect subsequent productivity. The variance in cognitive skills among children with the same number of years of schooling is generally high. Some of the variance is due to differences among children in such other inputs to educational production as ability and out-of-school investments in human capital made by parents, which are not directly influenced by government policy. Some of the variation, however, is due to differences in the quality of schooling, a policy variable. This implies that improving the quality of schooling is an alternative to increasing the quantity as a means of raising the skill level and productivity of the labor force. Most data sets are limited to measures of schooling attainment (grades, years, or levels of schooling) that preclude investigating the impact of quality differentials on cognitive achievement. For example, the only other data set of which we are aware that contains data on cognitive achievement of both students and teachers together with other socioeconomic information is that for Northeast Brazil, analyzed by Hanushek,

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Gomes-Neto, and Harbison (1992) and by Harbison and Hanushek (1992). But this data set includes neither preschool ability measures nor information with which to assess the impact of cognitive achievement on postschooling outcomes.

5. See the recent surveys in Fuller (1986); Haddad and others (1990); Hanushek (1986, 1989); Hanushek, Gomes-Neto, and Harbison (1992); Harbison and Hanushek (1992).

6. See Behrman and Birdsall (1983, 1985); Behrman, Birdsall, and Kaplan (1994); Behrman and Sussangkarn (1989); and King and Bellew (1988).

7. We consider a school to have been available if, when that individual was of the appropriate age for that school level, there was a school (for that person's gender) at that level in the same village or in a village sufficiently nearby that costs of travel did not preclude attendance by students from the same village in the same age cohort and of the same gender. Our school survey indicated whether a school was available in the village at the time the respondent was of school age. If a respondent was from a village not included in the school survey, we proxied school availability by determining the earliest date a respondent from the village attended school in or near the village. We verified, in villages in which we administered the school survey, that the proxy was an accurate indicator of the year the school was first available. For the ten to eighteen age cohort, just under 30 percent of those with some schooling attended primary school outside of their home village. Of course, the travel time to a school defined as available in this manner may be sufficiently great to discourage some students. For that reason, we include distance to school variables in the schooling attainment relation estimated below.

8. Where distance is not a factor, that is, when the school is located in the child's village, the conditional probability of attending school rises to over 90 percent for both boys and girls.

9. These decompositions are conditional on the assumption that school supplies are not determined importantly by local household demands, an assumption that is discussed further in the next section.

10. Increased cognitive achievement generally is thought to be a major product of schooling. There may be other products as well (such as increased discipline), but we do not have measures of them, so we proceed as if cognitive achievement is the key output of schooling (or is highly correlated with other products).

11. There are relatively few data sets for developing countries that include both earnings and cognitive achievement test scores. Those that do suggest that earnings are affected significantly by cognitive achievement (see, for example, Boissiere, Knight, and Sabot 1985; Glewwe 1990, 1992; Knight and Sabot 1990).

12. Students continuing in school usually complete two more grades (nine and ten) before sitting for the matric exam, then possibly two more grades (eleven and twelve) before taking the F.A. or F.Sc. exam, and possibly two more grades (thirteen and fourteen) before taking the B.A. or B.Sc. exam.

13. Of course, households may have some indirect effect on the availability and the characteristics of governmental schools through the political process. We do not have longitudinal data that would permit the investigation of whether unobserved community characteristics determine the availability and quality of local schooling (see Rosenzweig and Wolpin 1986; Pitt, Rosenzweig, and Gibbons in chapter 6 of this volume).

14. In our sample districts, there are no private schools. In principle, location (hence, availability of schooling) can be changed by migration. But migration is very limited within rural Pakistan (though there is more emigration from rural to urban areas). Fewer than 2 percent of respondents in our sample attended primary school away from the immediate vicinity of their village. Therefore we basically avoid the analytic problems due to migration that are discussed in Rosenzweig and Wolpin (1988).

15. We include in our analysis only the returns that are captured in earnings, not other effects of schooling such as those on health, nutrition, fertility, and enjoyment of leisure time. If such effects are positive, our procedure underestimates the returns on schooling. If they are more positive for females than for males as usually is assumed, this underestimation is greater for females than for males.

16. There are two cases where opportunity cost is relevant to investment in quality improvements. In the first case, the improved quality induces some increase in primary school enrollment; in the second, students are induced to extend their postprimary schooling because of higher-quality primary schools. In both cases, the private returns for such students must outweigh the private costs (including the opportunity costs) for them to be induced to attend school. Our estimate of the private rate of return on improving quality for students already in primary school underestimates the total returns on quality improvements by failing to incorporate these incremental gains (though it is possible that the incremental social costs of any additional publicly provided inputs outweigh the incremental private gains).

17. As noted below, our test of preschool ability was administered only to respondents ten years of age and older. Current measures of school quality are less likely to be valid for older respondents. The cutoff at age twenty-five balances the desire for more observations against the validity of our quality measures.

18. Since tests were administered only to persons with at least four years of schooling, scores had to be imputed for those with less schooling. Those with no education were assigned zero scores. (The scores of a subsample of the uneducated who were given the tests confirmed the appropriateness of this assignment.) Respondents with one to three years of schooling and qualified respondents who failed to take the test are kept in the sample for the estimates of the schooling attainment relations. Both tests have been used successfully in research on human capital accumulation and labor markets in East and West Africa (see Knight and Sabot 1990; Glewwe 1990, 1992; Behrman and Lavy 1994). We assume that cognitive skills so measured, perhaps several years after the completion of school, reflect the cognitive skills at the time of termination of school. That is, there is not subsequent investment or depreciation in cognitive skills. Estimates in Behrman, Ross, and Sabot (1991) indicate that time and experience subsequent to schooling do not affect cognitive achievement in our data. For this reason, we do not include age in the estimates that are presented below in table 8-4.

19. For example, 98 percent of boys completing four years of schooling had a middle school available, while fewer than 86 percent of girls had the option of continuing in school. Alderman and others (forthcoming, 1995) found no significant difference in the probability that boys and girls would go on to middle school were one available.

20. Since the tests were administered to people ten years and older, rather than preschool ability, it might be more accurate to refer to these tests as measuring ability that is independent of schooling. But such phraseology is cumbersome, so, with this caveat, we continue to refer to these test results as measuring preschool ability.

21. The average score on the Raven's CPM test, however, is roughly 6 points (out of a possible 35) lower for women than for men even though this test was designed to be gender neutral (Raven 1956). Court (1983) surveys forty-five studies in dozens of countries and concludes that observed gender differences in a minority of studies "do not justify the production of separate norms for the two sexes." But none of the studies of the CPM test that Court surveys was conducted in Pakistan or in other Islamic societies. The exploration of this phenomenon, which is reported in Alderman and others (forthcoming, 1995), tentatively suggests that this result is due to early childhood acculturation that is not otherwise related to the variables in the present analysis.

22. To obtain predicted income, we first regress current household income on parental characteristics, including education, employment, and acreage farmed, if any. We then use the parameters of this equation together with measures of the corresponding variables for each respondent's parents to obtain a measure of the parents' permanent income in 1989 rupees. Our regression explains 23 percent of the variation in household income. Seventeen of the twenty-four explanatory variables have statistically significant coefficients of the expected sign. Among the 846 households in our sample for which permanent income data could be calculated in this procedure, average household income is just over Rs23,000, with a standard deviation of Rs13,500.

23. Student/teacher ratios in our sample are higher than those published by Pakistan's Ministry of Education, which reports ratios of 34 and 36 for boys and girls, respectively, in rural Punjab and 36 and 34, respectively, in rural Sind in 1990. The gender difference in our sample can be explained by the tendency for girls' schools to draw mainly from the immediate village, while boys' schools often draw students from nearby villages as well.

24. When the latent schooling attainment variable exceeds threshold 1, we model the respondent as having attended at least some school. Threshold 2 corresponds to the completion of grade four, hence, eligibility to take the cognitive skills tests. Threshold 3 corresponds to completion of primary school.

25. A family background index was found to be insignificant for this sample and, hence, is dropped from the estimates reported here. The school infrastructure index also proved insignificant. The coefficients on the teacher quality indexes and student/teacher ratio variable are not affected substantially by dropping these other indexes. Adding other measures—for example, whether instruction is in the language spoken at home—to the teacher quality index alters the value of coefficients on the index components but does not alter the impact of the index on student cognitive skills. See Behrman and others (1993) for more details and for explorations of alternative specifications.

26. In our simulations, we use even insignificant coefficients as "best point estimates." Setting these coefficient values to zero does not alter the major implications of the simulations.

27. For example, for girls, teaching quality in reading at a low-quality primary school is represented by subtracting half the standard deviation (0.51/2) from the mean of the teacher reading quality index, 3.30, to yield 3.04.

28. No direct estimates of the contribution of cognitive skills to productivity in agriculture are currently available. Also, as we note above, we do not incorporate possible schooling effects on household production. The impact of education on wage earnings captures the impact of education on the shadow price of labor if factor markets are competitive or if segmentation of factor markets neither raises nor lowers the return on education in wage labor relative to the return on other activities. Alderman and others (forthcoming, 1996) find

no evidence of credentialist or screening biases in the educational structure of wages.

29. This procedure yields consistent estimates of the parameters. The corresponding ordinary least squares estimates explain 22 percent of the variation in log earnings.

30. Regional variations in distance to wage work and acreage farmed explain most of the regional variation in the probability of wage employment.

31. The total labor market experience variable is age minus fifteen or age minus the age that the respondent completed school, whichever is smaller.

32. BMI is defined as an individual's weight in kilograms/height^2 and has been widely used as an index for identifying obesity or malnutrition—and related health status—in adults in various societies in the epidemiological literature and increasingly in the economics literature. Cole (1991, p. 106) surveys the epidemiological literature and concludes that BMI "is the best weight-stature index" for such purposes. Fogel (1991a, p. 31) states that "Extensive clinical and epidemiological studies over the past two decades have shown that height at given ages, weight at given ages, and weight-for-height (body mass index) are effective predictors of the risk of morbidity and mortality." Behrman and Lavy (1994); Behrman and Wolfe (1987); and Fogel (1989, 1991b) are examples in the recent economics literature that use BMI extensively, with references therein to a number of studies that also use BMI.

33. The average body mass index for women is 0.091 points below that for men, implying a gender effect of $-0.248 - (18.15 \times 0.0094) = -0.419$.

34. The *F*-test on the latter equation provides no evidence that nonsalary recurring expenditures vary with any of our quality measures. However, teacher pay per student rises with teacher quality for reading and as student/teacher contact improves. Separate estimates indicate that teacher pay is positively related to teacher quality in mathematics. Apparently schools with high-quality mathematics teachers tend to have low rates of student-teacher contact.

35. Probit estimates find the probability of starting school as a function of distance (significantly different for boys and girls) and the cost of books, among other factors. By dividing the probit coefficients for the cost of books variable by the coefficient for distance to school, we obtain a rupee price for the impact of a minute of daily commuting time on the decision to go to school—1.74 rupees for girls, 0.38 rupees for boys.

36. Our sample includes a thirteen year old and a fifteen year old with no experience. Their wages do not differ substantially from the predicted wage. Our opportunity cost estimates are also consistent with the wages of other teenagers in our wage sample adjusted for years of experience.

37. Thus, the reported opportunity costs overstate the regional and gender differences a new entrant to the wage labor force would expect to face. In estimating rates of return below, it is the variation in the opportunity cost across alternative schooling investments rather than the opportunity cost itself that matters.

38. The choice of age of retirement has no effect on the relative ranking of returns. The value of work before age fifteen in the simulation is bracketed by the alternative opportunity cost assumptions.

39. The private returns estimates subtract public expenditures. The calculated private rate of return on improving quality would be infinite since the out-of-pocket cost is actually (marginally) smaller for the high-quality school.

40. Hanushek, Gomes-Neto, and Harbison (1992) argue that the rates of return on changes in schools that reduce repetition in Brazil would be very high.

41. In our sample, virtually all of the youngest boys have access to a primary school, so that this investment option is not likely to be very important.

42. We estimated preliminary versions of this regression using additive and multiplicative error terms with little qualitative difference in the results reported. As noted above, the variables in the teacher quality index are averages for all teachers at the school. The average teacher mathematics score is used to explain student mathematics scores; the average teacher reading score is used to explain student reading scores.

43. Our raw data indicate the actual number of years of schooling completed. However, because so few respondents completed certain intermediate years, we collapsed the number of schooling transitions to obtain reliable estimates of the thresholds.

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